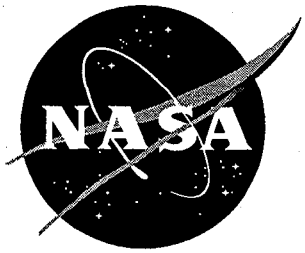

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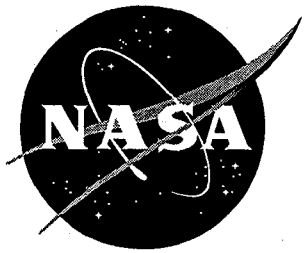

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February 1997

INSTITUTE STUDY REPORT

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1.0 INTRODUCTION

In early 1995, the NASA Centers began investigating the establishment of science institutes with the Agency's science workforce following the recommendations of the Zero Base Review. The NASA Chief Scientist expressed the goals of these institutes as: (1) strengthening the quality of science, (2) binding NASA scientists more effectively to the external community, and (3) coupling the external community to NASA's immense engineering and technical resources more effectively. In response to this activity, the Headquarters Office of Life and Microgravity Science and Applications(OLMSA) took the lead in developing a concept for an International Orbital Research Institute for Science and Technology to support the Space Station. Later, the program did not pursue this concept.

The specific Zero Base Review charge to MSFC was to study institutes in three areas - Global Hydrology, Space Sciences, and Microgravity. In response, MSFC formed an institute working group to research existing institutes, evaluate the OLMSA concept and to develop an institute concept(s) relevant to MSFC science. As the institute planning process proceeded, the focus of the MSFC committee became one of studying existing institutes, and identifying lessons learned for application to developing institute concept(s) for the specified discipline of microgravity science at MSFC. The microgravity institute was studied first because of its extensive involvement with the MSFC engineering workforce.

The initial step in the process of defining a MSFC institute model was the gathering of data on existing institutes thereby creating a benchmark data base. Having established this baseline set of data one could then make application of best practices and previous lessons learned toward the development of the MSFC model. To facilitate collection of this data, a questionnaire(included as Appendix I) was developed to collect information regarding existing institutes' organizational and financial structures as well as to identify the various strengths and weaknesses of those structures. It was further desired to identify research methodologies, interactive relationships with other agencies and various metrics utilized to evaluate their effectiveness.

The next step in the data process was to visit existing institutes or to invite their representatives to visit MSFC and describe their organizations. From this face-to-face interchange began the development of a sense for the culture of the institutes and of how they had succeeded in establishing effective and efficient organizations. An attempt was made to communicate with a wide variety of institutes in terms of size, product, and management methodology. A listing of all the institutes contacted is included as Appendix II.

The working group chose to rely largely upon the self-reports of each institute's director as the primary source of information. Such an approach makes the value of the assembled data highly dependent upon the accuracy of the institute director's understanding, his ability and willingness to communicate that understanding, and the group's collective capacity to accurately listen and appropriately synthesize the information. Most of the science institutes which were examined were in the applied research category. The directors tended to describe their institute operations in business terms which assisted in characterizing institute features relevant to replication or role-modeling interests. It was also noted that institutes with a purpose broader than basic science seemed to be more prolific, probably, for reasons inherent to their nature.

Ultimately, no institutes were visited. Either Institute Directors or Vice Presidents for Research presented to the working group and special presentations were made on topics such as the Centers for the Commercial Development of Space. Most of the remaining data was obtained through telephone interviews and submitted questionnaires. This report documents the team's observations and lessons learned relative to the mission, structure and operations of science institutes.

1.1 INSTITUTE MISSION

Institutes were established to serve a number of purposes. Their missions were usually well-focused in areas of research and closely tied to the goals of the sponsoring organizations. While an institute concentrates knowledge and expertise in an area of research, it may also serve as a means of gathering and disseminating data relative to this particular area. In some cases, institutes were structured to

aid the local economy since their presence encourages industry to locate nearby. Most institutes were formed with a university association to provide the open, academic environment that promotes creativity, the interchange of ideas, and teamwork. Being associated with a large, well-known university was seen as a key element in attracting nationally known researchers, as well as industrial interests to an institute.

The mission emphasis of the institutes which were studied ranged over the continuum from applied to basic research. Basic science institutes, as their name implies, tended to concentrate on research while maintaining a wide external collaboration with the scientific community to sustain cutting-edge research and credibility with that community. Applied research institutes tended to aim their research toward commercial products and thus have more industrial partners. Institutes were involved not only in research and technology development but promoted education and training as well. They usually had a strong, visible presence in the community.

The mission of an institute determined the way it did business, its structure and the evolutionary path undertaken. Basic research institutes were closely tied to the university community, whereas the more product-oriented institutes tended to expand, weaken their university connections, and then become "research for hire" organizations. In some cases where an institute had produced a "product line", it spun off a separate center to concentrate on production leaving the institute itself essentially unchanged.

The evolution of an institute and its mission was observed to be closely tied to the reliability of its core funding, the independence it exercised, and the vision of its Director. In those cases where core funding ceased, the institute changed its mission in order to survive. For example, an astronomy institute whose major funding disappears might increase its emphasis in associated areas of high demand, such as optical coatings development.

1.2 ORGANIZATION

1.2.1 STRUCTURE

The working group looked at a wide variety of research institutes, including institutes which were part of (or closely associated with) a single university; institutes which were affiliated with a group of universities; institutes which were independent of any university; and institutes which consisted of a partnership between a university and an agency of the federal government. While it is difficult to generalize about the structure of such a diverse group of institutions, there are a few characteristics that are common to nearly all of the institutes that were observed.

In many cases, the group found that the institutes performed their research activities with interdisciplinary teams. Team members were matrixed to these activities from line organizations of scientific and engineering disciplines. Larger projects usually were separate organizations headed by a project manager and a small group of "generalists" working in teams. They utilized experts from each of the scientific or engineering disciplines represented in the line organization.

Another characteristic which the group found to be typical of nearly all the institutes studied, was the fact that administrative functions (purchasing, personnel, finance, etc.) were consolidated into an organizational element, or group of organizational elements, (depending on the size of the institute) which reported to the institute director. Resources(human, financial, physical, etc.) were normally closely controlled at that level through these administrative elements. Generally, the administrative staff was representatively small.

In all of the institutes studied, independent of size(which ranged from less than one hundred to about twenty-eight hundred people), management layers did not exceed three levels. In the larger institutes, the use of computer networks and reliance on individual responsibility for administration were more evident.

1.2.2 THE INSTITUTE DIRECTOR

One factor that was frequently cited as absolutely critical to the success of a research institute, particularly in the early years of its existence, was the selection of the right individual to head the institute. Many of the institute representatives stated that selecting an individual, who was well respected for their work in the field of research pursued by the institute, was essential. However, equally important was, what some described as "entrepreneurial spirit". The ability and the drive to recruit a top-level staff, negotiate for office and laboratory space, acquire equipment and funding, and attract business to the institute, while keeping an eye on the bottom line, were generally acknowledged as being "must have" qualifications for an institute director.

An effective institute director was provided with the power to hire, promote, fire, and to set salaries with minimal restrictions. Also, they had the authority to allocate financial resources where needed. These two factors were often stated as being crucial to the effectiveness of an institute director.

1.2.3 BOARD OF DIRECTORS/ADVISORS

The institutes structured by universities varied a great deal in the degree of independence which they had in their relationship to their parent university. Those with close ties to the university had directors who reported to the university's Vice President for Research. Typically, the more independent the institute, the greater the likelihood that the head of the institute would report to a board of directors. The board of directors was traditionally drawn from groups who had a vested interest in the institute. All institutes had advisory boards, and some large institutes had multiple advisory bodies, whose mission was to provide advice on different aspects of the institute's operation. Members of these advisory boards and panels were consistently drawn from outside the institute itself and occasionally represented groups or entities which had a stake in the success of the institute. Views on the value of such advisory boards were mixed.

1.2.4 WORKING ENVIRONMENT

Representatives of the institutes which were examined, frequently made the statement that the success of their organization was attributable to the quality of the personnel that they had been able to attract. Recruiting and retaining the best qualified people working in the field was often mentioned as the critical factor in maintaining a national reputation. This was also mentioned as a gauge for measuring an institute's success.

Several factors were cited as having a positive impact on the ability of the institute to attract and retain high quality scientific and engineering talent. Frequently cited steps that an institute could take to attract and retain top level talent included (in no particular order): (1) providing top level facilities and equipment; (2) locating the institute in a geographical area where people want to live and work; (3) locating the institute on or near the campus of a university in order to provide an "academic" environment; (4) having eminent scholars in the field on the staff of the institute; (5) providing adequate funding; and (6) allowing engineers and scientists to take part in the financial rewards from their discoveries and developments.

The majority of the institutes studied were housed on a university campus. This arrangement had a number of advantages, as well as some drawbacks. Being located on or near the campus of a university tended to strengthen the institute's ties to that university, as well as facilitate interaction with other scientists, mathematicians, engineers and scholars from the university. A campus location facilitated interaction with graduate students, who were an important manpower resource with respect to much of the research conducted by the institutes. Locating an institute on a university campus also contributed to the kind of academic environment favored by many scientists. An on-campus location was often a low cost alternative. However, available space on campus was often limited and the competition for such space was often intense. Locating an institute on campus may limit the ability of the institute to grow, and in cases where competition for space is particularly keen, it may even jeopardize an institute's continued existence.

Representatives of the institutes which were studied stated that great scientific work required proper facilities and equipment. This was helped by having an atmosphere where ideas could be exchanged freely with the "best" minds in the field. People would compete for the opportunity to work in such an environment even when it meant passing up more lucrative positions at institutions which had less to offer intellectually.

1.3 RESEARCH ARRANGEMENTS

1.3.1 AGREEMENTS

The institutes surveyed utilized a number of different agreements to conduct their research. The type of agreement which was employed depended, in part, on the entity executing the understanding with the institute, the intent of the research, and intellectual property considerations.

In the performance of efforts for the Federal Government, institutes used grants; cooperative agreements; Cooperative Research and Development Agreements(CRADAs); cost reimbursement contracts; Space Act Agreements; cost share contracts and Federal facility operations contracts. In one instance, a Federally Funded Research and Development Center contract(FFRDC) was in place.

Usually, if the government was purchasing services or a product then a contract was appropriate. If research did not require substantial involvement by the government, a grant was used. If there was to be substantial government involvement, a cooperative agreement was utilized. A Memorandum of Understanding was used where the parties did not intend to create legally enforceable rights. This was the least formal of the arrangements. Space Act Agreements were used when no funds were to be exchanged but assets and capabilities were brought to the table by each party to accomplish the research. Sometimes, CRADA's were used similarly but instead of the authority being the Space Act, the Stevenson Wydler Act was used. The FFRDC was used to bring an organization into existence at the initiative of the government to meet a special R&D need which could not be met as effectively by existing in-house or contractor resources.

Institutes in their relationship with private industry utilized the following: research contracts; research agreements; informal no-cost feasibility agreements; subcontracts; membership agreements; memoranda of understanding; cost-sharing agreements; and technical support-type agreements.

The methods for interacting with private industry ranged from contracts in which private industry largely procured a service from the institute to Memoranda of Understanding wherein each party brought its assets and talents to the table. In using contracts with industry to provide research services for solving problems, the institutes usually used a cost reimbursement no-fee contract, however, they also entered into cost share arrangements. On the other side of the spectrum, institutes used informal agreements for feasibility analysis on a no-cost basis. Regardless of the formal mechanism, it was noted that there was close and extensive contact between industry and the institute.

The main point repeatedly made by the institute representatives was that they have significant flexibility on the type of instrument used in conducting their research with both industry and government. In essence, they attempted to be very customer oriented.

1.3.2 INTELLECTUAL PROPERTY RIGHTS

Institutes and their "customers" were sensitive to intellectual property rights issues. The rationale for such sensitivity was that intellectual property ownership was a potential revenue generator.

Institutes utilized various intellectual property provisions in the documents entered into with entities. Confidentiality agreements were used by institutes to protect information obtained from sources. Patent and royalty agreements were used that varied from the institute retaining ownership rights, to the "customer" obtaining such rights where the relationship was more of a contracted effort for the "customer." Certain arrangements allowed the anchor university to hold title with the consortium membership receiving non-exclusive, royalty-free licenses for use internally. In some circumstances, royalties generated from a license would return to the institute where the license was used to make and sell a product. One institute selected a senior investigator for a project and let this individual determine who received the intellectual property rights.

In another, the customer had a "first right of refusal" to the intellectual property rights.

The institutes did not have problems with the government prescribed intellectual property clauses in the various types of agreements used by the government. In essence, the institutes were willing and capable of negotiating intellectual property rights that accommodated the particular circumstances of the research and the desires of their customers.

1.4 BUSINESS

1.4.1 MANAGEMENT

There was a number of factors that significantly influenced the way that institutes structured their business management operations. The size of the institute budget and number of personnel, the institute's status as a government or non-government entity, the participation of civil servants, and the extent of industrial involvement were all significant considerations. Institutes that did not have civil servant participation, tended to model their business management approach along the lines of a small-to-midsize company with centralized business functions that were the focal points for accounting, budgeting and purchasing. Some included personnel and facility operations as well. The larger the institute, the more likely it was to have a separate human resources department and separate facility operations department. Further, the larger institutes recognized the importance of the business management function and had established vice-president positions to manage this area.

The presence of government employees in the institute complicated the single business approach because of the significantly different and specialized rules imposed by government regulations on personnel practices, travel, etc. The simplest approach to this matter was to maintain segregated business and personnel management functions. Effectively then, the institute was scientifically integrated but administratively divided except for a common Director. Several of the institutes studied were sovereign entities of the state government. To reduce the complications in contracting, one of the state entities established a private corporation to handle the funding arrangements to and from the institute.

There appears to be an institute "critical mass" required to attract and sustain business. Several representatives mentioned that the budget number lay around the $10m/year mark. In many cases, industry participated with the institute to select the research areas to be pursued, becoming, as one institute noted, the "visiting board of directors". Typically, these "member companies" paid a moderate fee. They also made available equipment and personnel on a part-time basis to contribute to the success of the institute. Member company participation was enhanced by giving them the opportunity to influence considerably the directions taken in the university research programs as well as granting them access to the technology developed.

1.4.2 FUNDING

Substantial budgets were necessary for institutes to have significant programs not only in science, outreach, and education, but also in enabling engineering development. The latter is potentially a key to increasing participation by industry. Mission sponsors tended to limit the amount of outside support an institute could have from other sources so that reasonable conformance to the mission of the institute could be maintained. Institutes generally encouraged their personnel to pursue outside funding to expand the base of the institute.

While funding may be expected ultimately to come from a growing variety of sources, dependable, long-term core funding was crucial. Such funds represent a stabilizing commitment. Without this, it will be very difficult for private institutions or consortia hosting an institute to risk putting in place a workforce, and other substantial assets. The availability of matching resources from research partners are inter-related and depend on the scale of the core funding. All of the institutes studied depended heavily on government resources. Even independent, applied research institutes appeared to begin with very significant levels of government funding(usually from a single source), sustained significant support for a decade(more or less), and were gradually able to supplant some of the funding through multiple sources such as other government agencies and industry partnering. The "tapering off" of government support was not by design usually, but was the result of budget cutbacks. The institutes providing data relative to their annual funding depended on governmental funding ranging from fifty-nine percent to one hundred percent of their total funding.

1.5 METRICS

What constitutes a successful institute? That it exists at all, may be one measure. That it continues to thrive after two years may be another reasonable gauge, particularly since it appears that institutes undergo "reinvention" every two to five years. Some institutes failed for a variety of reasons - unrealistic expectations of its board of directors; loss of core funding; incompatibility of director and institute mission; cultural and work ethic differences. Clearly, an institute must thrive to survive.

Judging the success of an institute depends not only upon static measurements used to assess the achievement of its goals and mission, but in examining its capacity to alter its purpose and nature. The ability of an institute to reinvent itself, to be forward-thinking, flexible and creative enough to survive dynamic challenges is difficult to quantify.

Most science institutes measured performance by the number of refereed papers published, the number of citations in published papers, and awards granted against submitted proposals. University-based institutes also included the number and quality of graduate students supported, doctorates produced, faculty awards earned and educational seminars hosted in their criteria for success. Independent institutes tended to be more focused on business metrics, using revenue goals, customer feedback, project performance, budget, and schedule measurements to assess their level of success. Applied research institutes added the number and nature of technology transfer transactions, product developments, and industry alliances to their list of performance measurements.

1.6 SUMMARY

Data have been collected on a gamut of successful institutes that varied in size, structure and product. While there are diversities of approach and uniqueness of structure, there do appear to be some common factors which might be considered instrumental to the success of an institute. Some of the more important factors are included in the following comments.

- The Director of the institute is the key to success. This person should be visionary and entrepreneurial with strong managerial qualities. If the institute concentrates on basic research, it is important that the director be well respected in the scientific community.

- Most successful institute organizational structures are flat and highly flexible with a great deal of informality in internal interaction across organizational lines.

- Generally, a board of directors with political, industrial and community connections, along with a vested interest in the institute's success is a significant factor in the survival and growth of the institute.

- In general, administrative staff should be kept to a minimum.

- In the beginning, it is preferable to locate the institute on or near a university campus to take advantage of the availability of university facilities, professors and students.

- Practice has proven that development of top quality facilities and equipment and association with top researchers in a chosen field will attract other key research personnel to an institute.

- Efforts should be made to attract funding from as broad a base as possible with the expectation that this base will evolve over the years.

Appendix I

RESEARCH INSTITUTE QUESTIONNAIRE

1. How is your institute organized? (Please include an organization chart.) If you could begin with a clean slate, what changes would you recommend?

2. Describe your institution's personnel and facilities.

3. In your judgment, what are your institutions key strengths as far as organization?

4. What major problems have you encountered over the years? What suggestions do you have for reducing/dealing with these problems? (Lessons learned)

5. How is your research institute funded (Federal, state, industry, other)? How do you attract customers, i.e., academia, industry, and government, to your institution?

6. How do you interact with the industrial research community? What mechanisms do you use? (Co-operative agreements, contracts, formal versus informal agreements)?

7. How do you circulate, distribute, or promote the findings or results of the institute's research? How do you maintain the proprietary data, avoid conflict of interest, and protect the interests of the organizations that sponsor and/or fund the research?

8. Identify opportunities and limitations for a combined research institute, i.e., academia, government, and industry. (Funding level required by each partner both money and in-kind? Any special arrangements required with industry)?

9. How much are personnel from various sectors involved in carrying out the mission of the Institute (i.e., from the Institute, Government, industry, and other academic or research organizations)?

10. What is the ratio of basic to applied research at your institute?

11. What modes of communication are used to promote teamwork from people working away from the Institute?

12. What metrics are used by the Institute, by Government, and by industry to evaluate effectiveness of operations?

Appendix II

INSTITUTES STUDIED

- Center for Advanced Research in Biotechnology (CARB)
- Center for Astrophysics (Smithsonian Astrophysics Observatory + Harvard College Observatory) (CFA)
- Georgia Tech Research Institute (GTRI)
- Global Hydrology and Climate Center (GHCC)
- IIT Research Institute (IITRI)
- Institute of Geophysics and Planetary Physics (IGPP)
- JILA (formerly Joint Institute of Laboratory Astrophysics)
- Lunar and Planetary Institute (LPI)
- Research Triangle Institute (RTI)
- Southern Research Institute (SRI)
- Space Power Institute (SPI)
- SRI, International (formerly Stanford Research Institute)
- University of Tennessee Space Institute (UTSI)

Seven Centers associated with the State of Georgia and Georgia Tech

- Advanced Technology Development Center (ATDC)
- Army Environmental Policy Institute (AEPI)
- Education, Research and Development Association of Georgia Universities, Inc (ERD)
- Georgia Research Alliance (GRA)
- Manufacturing Research Center (MARC)
- Packaging Research Center (PRC)
- Southern Coalition for Advanced Transportation, Inc. (SCAT)

- Three Centers associated with SRI and *IITRI*

- Failed Institutes (General Data)

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This report documents a study conducted by the MSFC working group on Institutes in 1995 on the structure, organization and business arrangements of Institutes at a time when the agency was considering establishing science institutes. Thirteen institutes, ten science centers associated with the state of Georgia, Stanford Research Institute (SRI), and IIT Research Institute (IITRI), and general data on failed institutes were utilized to form this report. The report covers the working group's findings on institute mission, structure, director, board of directors/advisors, the working environment, research arrangements, intellectual property rights, business management, institute funding, and metrics.

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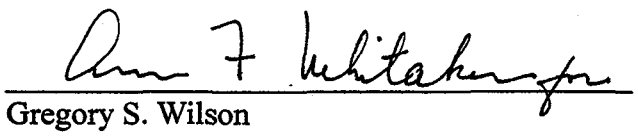
By A. F. Whitaker, J. Steadman, S. Little, D. Underwood, M. Blackman, and J. Simonds

The Information in this report has been reviewed for technical content. Review of any information concerning Department of Defense or nuclear energy activities or programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.



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